A FEW FACTS CONCERNING THE RELATIONSHIPS AND REPRODUCTION OF SOME BERING SEA TUNICATES.

WM. E. RITTER.

WHILE President Jordan was engaged, as commissioner in charge of the fur-seal investigations for 1896, in studying the natural history of the seals of the Pribilof Islands, he collected a considerable number of tunicates. These he kindly intrusted to me for study. They proved to be so interesting that during his second summer's work (1897) in the same capacity he encouraged the enthusiastic young zoölogists, R. E. Snodgrass, A. W. Greeley, and Trevor Kincaid, who accompanied him, to give particular attention to collecting these animals. The result was a large, well-preserved collection, the study of which contributes substantially, in several directions, to our knowledge of the group. These contributions will appear in detail as a part of the final report of the scientific investigations made by the commission, to be published later by the United States Government. Some of the facts brought to light are, however, of sufficient consequence to make worth while their publication in advance of the report itself. I consequently present them here. As indicated by the title of the note, they relate to the affinities of the Bering Sea tunicate fauna and to the reproduction of some of the species studied.

The collection contains eleven species, ten of which are new to science. These are distributed among seven genera in the following way: *Boltenia*, *Styela*, *Aplidiopsis*, and *Synoicum*, each one species; *Dendrodoa* and *Polyclinum*, each two species; and *Amaroucium*, three species. So far as I am able to determine, no tunicates have before now been described from this portion of the world, the northern species hitherto known having come from the North Atlantic and Arctic oceans, mostly

from the vicinity of the Scandinavian peninsula. The addition of these species to the others already known from far northern seas increases quite to a certainty the probability that there is a distinct Arctic tunicate fauna. The clearest indication of this is afforded by the presence in the collection of the species of the genera *Dendrodoa* and *Synoicum*. The single species of the first-mentioned genus hitherto known was described by MacLeay in 1824 from Winter Island (north of British America). Herdman has expressed doubt as to whether or not MacLeay's genus is really distinct from *Styela*. From the two species now at hand I have convinced myself that the genus is thoroughly valid — much more so than many others that receive general recognition. This, then, appears to be one characteristically Arctic genus. The other genus above mentioned, *Synoicum*, seems to be quite as characteristically Arctic. The first species belonging to it was made known by Phipps (1774), and more fully described by Savigny in 1816, and came from Spitzbergen. Since then another species from Lofoten Islands, north coast of Norway, has been described by Sars. This, then, seems to be another genus characteristically northern.

Of the other species the one belonging to the genus *Aplidiopsis* has its nearest ally in *A. sarsii* Huitfeldt-Kaas, from Lofoten; and two of the three species of *Amaroucium* appear to be more closely related to *A. mutable* Sars, from Hamerfest, Norway, than to any other member of this large genus. The one representative of the genus *Boltenia* I identify as *B. elegans* Herdman, from the north Atlantic; so that six of the eleven species may be said to be characteristically far northern, three of them very pronouncedly so, they belonging to genera that are exclusively of this character. The genera *Polyclinum* and *Amaroucium* are both cosmopolitan in their distribution; they are almost sure to be represented in any considerable collection of compound ascidians from any part of the world, so that it is only by comparing among themselves the different species in each genus that anything significant as to distribution can be learned.

The facts which I here present relating to reproduction pertain to *Synoicum*[1] alone. They are, in outline, as follows:

On examination the colonies are found to contain zooids in various stages of degeneration, as well as those in a normal condition. Some of these degenerating individuals are without the thorax; others, again, are lacking both thorax and intestinal loop, the post-abdomen alone being present, this latter, however, retaining quite its normal form and structure. In still other zooids the post-abdomen, which alone remains, is reduced from its original club shape to a spherical form.

The post-abdomen, as with all the polyclinidae, lodges the heart, the epicardiac tubes, the sexual organs, and a variable quantity of mesenchymatous tissue, the cells of which contain a characteristic granular material which apparently is food yolk. This last-mentioned substance constitutes, in this species, by far the major portion of the bulk of the post-abdomen at the time when the latter becomes free from the rest of the zooid.

The ova at this time appear to be all contained in the compact band-shaped ovary, and are in many stages of growth. They are all, excepting the very largest, almost entirely free of yolk; they possess neither recognizable follicular epithelium nor "test" cells, and *they are distinctly amoeboid in form.* Careful examination of the ova discovers that many of them, particularly the larger ones, contain within the substance of the cytoplasm other cells in various stages of disintegration. They are ingesting other cells; they are clearly amoeboid in habit as well as in form.

Beside the amoeboid ova contained in the ovary there occur, in some of the post-abdomens that have become more nearly spherical in form, ova in which the amoeboid character is wholly wanting, they being quite spherical in form and regular in outline. In these ova, which are also considerably larger than the largest amoeboid ovarian ova, the cytoplasm is no

[1] *Synoicum* is a compound ascidian in which the colony is composed of a number of lobes arising from a common basal mass. Each of these lobes consists of a groundwork, or matrix, of firm, homogeneous testicular substance, in which are imbedded a small number of zooids.

longer homogeneous and clear, but is filled with granular substance. In some of these last-described ova the nucleus still maintains the large, clear, spherical, vesicular character which it presents throughout the amoeboid period. In others, however, it is indistinguishable. This last condition probably indicates the period of maturation.

In addition to these several stages of development of the ovarian ova, numerous stages, from the two-celled stage onward, in the development of the embryos have been found.

Finally there occur numerous packages of tadpoles, each package containing from ten to sixteen or more individuals, situated in cavities of the semi-cartilaginous test of the colonies. These cavities are almost perfectly spherical, are remote from the surface of the colonies, and are entirely closed. They contain nothing but the closely packed tadpoles; and after these have been picked out the firm, smooth walls of the cavities remind one of bullet molds.

The tadpoles themselves are enveloped by an unusually thick layer of what in all probability corresponds to the test formed at an early time in the embryonal life of all ascidians. But it contains an unusual number of cells, and in addition bodies of various kinds, which I can account for in no other way than by supposing them to be remnants of the parental zooids which produced the ova.

In fact, there is little room for doubt about the nature of some of them. Thus, in one instance in particular, a small cluster of them resembled the large yolk containing mesenchyme bodies of the adult zooids so strikingly that I should not have thought of questioning their nature but for the remarkable position in which they occurred.

Besides these bodies, pieces of fibers are found which are almost certainly remnants of the muscle fibers of the paternal mantle.

In some instances the tadpoles are in an advanced stage of metamorphosis while still contained in the cavities.

Mature spermatozoa, as well as others in various stages of development, are abundant in most, if not in all, of the post-abdomens.

Unfortunately, the collection does not contain sufficient specimens of this species to enable me to answer several questions of fact that arise from a consideration of the observations presented. However, the facts that we have scarcely admit of misinterpretation. When the post-abdomen first becomes free from the parent zooid, the ovary contained in it has a large number of ovarian ova in various stages of growth. That some of these mature, become fertilized, and develop into tadpoles is proved by direct observation. When the full tadpole stage is reached, only a very limited number of individuals — ten to sixteen — is present in each cavity, and the cavities contain nothing else than the tadpoles. The ovarian ova are distinctly amoeboid in form and certainly contain ingested cells. The conclusion seems inevitable that by far the larger portion of the ova of each ovary are consumed as food by the few of the same ovary that develop into embryos; furthermore, that the granular material (food yolk) of the parental mesenchyme cells is also made use of as food by the growing embryo, and that probably other tissues of the parent zooid are used, to some extent at least, in the same way.

The absence of follicular epithelium and "test" cells from the ovarian ova is undoubtedly correlated with the amoeboid nature of the ova; but it is quite possible that their absence is more apparent than real. Some of the cells ingested by the ova may represent either follicular or "test" cells, or both. The observations also seem to indicate that the test, or "cellulose mantle," of the late embryos and tadpoles engulf various portions of the parental zooids, and this suggests that the embryos are in some way nourished by this means. Such a process, however, would be quite remarkable, and further observations on the point are greatly to be desired.

UNIVERSITY OF CALIFORNIA, February 10, 1898.